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MILL TEST AND CONCLUSION LEADING TO THE DESIGN
OF AN ADDITION TO FLORIDA PEBBLE PHOSPHATE
CONCENTRATOR

BY
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A
THESIS

submitted to the faculty of the
SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI
in partial fulfillment of the work required for the
Degree of
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Approved by _____
Associate Professor of Metallurgy.

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Existing Conditions of Milling

The fact that 30 o/o to 50 o/o of the phosphate mined in this district is lost as tailings due to an inadequate method of concentration has caused no small concern and many attempts have been to develop a method, of economic value, for saving the phosphate lost.

Possible Methods of Saving Waste Phosphate

The Sp. G. of phosphate rock and sands of the matrix are approximately the same, so no separation can be effected here. There is a marked difference in the hardness that of the phosphate is between 3 and 4 the other constituents are harder. A possible method might be developed along this line, of passing the tailings through a tube or "Ball Mill" with a combination of screening. So far this has not proven worthy of the expenditure. The cost of operation and installation prohibiting. A There is a difference in fusibility and a separation could be made here but is obviously impracticable., also that of leaching by chemical means. A possible economic separation might be made by static electrical current. The present practice is washing and screening recovering only that phosphate larger than the sand.

Deposit

The phosphate bearing conglomerate has been accumulated from the underlying Alum Bluff formation under Marine or Estuarine conditions(1) accounting for the fineness of the sands of the matrix, the size of sea sand, the only material larger except the phosphate pebbles are fossil remains and iron accretions, the only other interfering condition in concentration larger than these sands are clay balls accumulated in mining. The objectionable impurities in the finished product are iron, aluminum and silica; Such impurities as fluorite and calcium carbonate are not in sufficient quantity to cause comment in the manufacturing of the fertilizer, a small amount of calcium carbonate is a help rather than a detriment.

The analysis of the dried conglomerate as mined that will produce a finished product of 75% B.P.L. (Bone Phosphate of Lime) Tri-Calcium phosphate is.

Moisture	.78
Insol. Matter	25.18
Phosphoric Acid	26.73 - B.P.L. 58.38
Iron and Aluminum	7.51
Calcium Oxide	1.02

Mining

As the method of mining figures in the concentration of the phosphate an outline of this process will not be out of place. Both Over-Burden and phosphate bearing conglomerate are mined by hydraulic methods. The water is supplied by pumping engine, using 2000 gal. or more per minute on the over-burden and 2600 gal. or more in the mine and washer. The washer uses about 600 gal. per minute. The bank is cut down by the water, using generally two monitors to the outfit, and drifted to the suction of a 10 inch centrifugal pump.

Washer and Screening Plant

The matrix from the mine is discharged onto a stationary flat screen of punched $3/16$ by $1/2$ inches having a slope of 1 in 12, this slope varies however with the nature of the deposit; This screen is 8' by 16' and discharges into a revolving screen known as a "Seperator" punched hit and miss with holes $1 1/2$ diameter, and have spiral flights or blades riveted to the inside so as to retard the passing of the clay balls and larger fossil fragments, allowing a better opportunity for disintegration. The oversize from the seperator is discharged as tailings. The undersize discharges into another flat screen of the

same dimensions as the first screen; The undersize from both flat screens discharge as tailings; The oversize passing into the logwasher, which consists of two logs, set on an incline towards the discharge end and are 20 ft long; The over flow at the back or lower end of these logs discharge as tailings; The heads discharge into a double rotary screen, the inside metal is punched with $3/8$ " by $1/2$ " holes, the oversize passing into a crusher, the undersize onto the outside screen. The outside screen is punched $3/64$ " by $1/2$ ", the undersize from this screen discharging as tailings and the oversize discharging into a second set of logs, the discharge from the crusher also goes to this set of logs. The crusher consists of a shaft with 3 sets of spiral flights extending from each end to the middle, the spirals from each end running in opposite directions, these flights are 8" high and $1-1/4$ " thick and 4' long over all. Each flight is set so it passes through 60° on the shaft; this part is known as the "tumbler" and rotates in a half-circle-grizzly, with bars set $3/8$ " apart and in the direction of rotation. The "Tumbler" pulls the rock under and forces it through the grizzly, completely crushing, scouring and disintegrating any mud balls or cemented matrix that may be left in it from the logs

From the second set of logs the rock passes into a second rotary screen of the same dimensions of the first, the overflow from the logs and the undersize from the screen going as tailings the oversize from the screen is the finished product at the mine and washer and is discharged into the wet bin.

Drying

From the washer the the rock is hauled to a central drying plant equipped with 8 revolving dryers 42" in diameter. An average consumption of 5-1/2 lbs. 12 Be Mexican Oil being used per ton of rock dried to Less than 2% moist. This plant has a storage capacity in the shape of a concrete bin capable of holding 40,000 tons of dried rock.

Test of The Washer

The following data was collected from a mill test of the washer and in conclusion from which the attached plans were drawn for an addition to the washer to save that portion of the rock between 1/32" and 3/64". As it was necessary to know the quantity of water to be handled as well as material, tanks were built large enough to catch the entire product from that portion of the washer to be tested, long enough to obtain a good average sample. As the quantity of both rock and water vary it was necessary to carry

The test over several days to obtain a workable average. Both Flat screens were treated as one unit.

Flat screen, punched screen metal, $3/64$ by $1/2$ " holes

UNDERSIZE

1050 gallons per minute

354.6 lbs. dry wt. of solids per minute

21300 " " " " " " hour

30.2# phosphate under $3/64$ and over $1/32$ per min.

1812# " " " " " " hour

Also found a loss of 30.0 #/minute of rock due to worn screen metal. Possible to save from this source 43,200# or 21 tons per 24 hours that would pass through a $3/64$ screen and be caught on a $1/32$ screen and the following analysis are from average samples from the screening tests of above.

Sample	Location	B.P.L.	Fe. & Al.	Insol
A	Through $3/64$ " Total	34.04	2.55	54.30
B	Less than $3/64$ over $1/32$ " -	70.34	2.83	67.78
C	Through $1/32$ "	27.00	3.11	63.62
D	Through bad screen, over $3/64$ " -	70.71	2.97	6.07

Making a saving of 21 tons per 24 hours of 70.34%

B.P.L., marketable phosphate valued at \$3.00 per ton.

OVERSIZE Flat Screen

The over size from the flat screen passes into the first set or No.1 logs, average as follows

620 gal. per minute

7 26# dry solids per minute.- Sample marked "E"

4 35 60# per hour

Analysis

Sample	B.P.L.	Fe.&Al.	Insol.
E	Number 1 63.43	3.08	13.43

Number 1 Logs
Number 1 Logs

Tailings through overflow at back of logs

OVERFLOW

590 gal. per minute

94# dry solids per Minute.- Sample marked F

5640# dry solids per hour

810# " " " "over 1/32" - Sample marked G

4830# " " " "under 1/32"- Sample marked H

Sample	Analysis	B.P.L.	Fe.&Al.	Insol.
--------	----------	--------	---------	--------

Sample	B.P.L.	Fe.&Al.	Insol.
--------	--------	---------	--------

F	24.96	2.80	68.37
---	-------	------	-------

G	67.70	3.10	9.42
---	-------	------	------

H	23.02	3.14	70.93
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HEADS discharge into rotary screen number 1. Sample marked I

Analysis

Sample	B.P.L.	Fe.&Al.	Insol.
I	62.91	2.69	17.40

Rotary Screen No.1. Inside screen 3/8" x 1/2", Outside screen 3/64" x 1/2".

UNDERSIZE; From 3/64" x 1/2 Outside screen-Tailings

184 gal. per Minute.

4080# dry solids per hour.

420# " " " " over 1/32". Sample marked J

3660# " " " " under 1/32" Sample marked K

OVERSIZE or Heads.

Undersize from inside screen and oversize from outside screen discharge into No.2 Logs. Sample marked L

Oversize from inside screen discharge into crusher (Over 3/8" in diam.) Sample marked M.

Analysis

Sample	B.P.L.	Fe.&Al.	Insol.
J	63.42	2.96	6.11
K	26.55	2.16	63.83
L	55.71	8.22	20.54
M	66.92	22.70	12.03

Number 2 Logs. Heads from Outside Rotary Screen and Discharge from Crusher.

TAILINGS-Overflow at back of logs

108 gal.per min. —

541# total sand per hour ,dry weight. Sample marked N
7.5 dry weight per hour , over 1/32" ,Sample marked O
533.5# " " " " under 1/32" Sample marked P
HEADS-Discharge into No.2 Rotary Screen. Sample marked Q

Analysis

Sample	%B.P.L.	% Fe.&Al.	%Insol.
N	38.37	8.50	44.53
O	67.28	3.05	10.20
P	37.06	8.11	46.49
Q	64.60	2.70	14.75

Number 2 Rotery Screen-Heads from #2Logs
UNDERSIZE-From 3/64" x1/2" Screen
177 gal.per Minute.

4500# dry tailings per hour. Sample marked R
464# dry rock per hour over 1/32" Sample marked S
4036# " " " " under 1/32" Sample marked T
Heads-Over 3.64";Finished product to be dried./

Analysis

Sample	%B.P.L.	%Fe.&aL/	%Insol.
R	38.06	2.88	47.20
S	67.15	2.92	11.90
T	34.17	3.41	53.68
U	69.52	2.99	6.85

FLOW SHEET

MINE RUN

3000000 gal. water per 24 hours
1500 cu. yds phosphate matrix per 24 hours

FLAT SCREEN, Punched 3/64" x 1/2"

Oversize

Undersize

SEPERATOR-Punched 1-1/2" diam.
holes. (Trommel)

Undersize

Oversize
Tailings & waste

FLAT SCREEN) Punched 3/64" x 1/2"

Over size

Under size

620 gal per min.
43560# Rock per hour
63.43% B.P.L.-3.08%Fe.&Al.
13.43% Si.O₂

To SHAKER SCREEN
1050 gal per minute
21300# sand per hour
Saving on 1/32" screen
1812# per hour.
70.34% B.P.L.-2.83%FeAl
7.78% Insol.

NO.1 LOGS

Heads

62.91%B.P.L.-2.69%Fe.&Al.
17.40% Insol.

To SHAKER SCREEN
Oversize Undersize
to bin Tailings

Overflow

To SHAKER SCREEN

NO.1 TROMMEL

Heads

66.92%B.P.L.-2.7Fe.&Al.
12.03% Insol. (CRUSHER)

590 gal per min.
5640# sand per hour
Saving on 1/32" screen
810# per hour.
67.70%B.P.L-3.1%Fe.&Al
9.42% Insol.

and

55.71%B.P.L.-8.22 Fe.&Al.
20.54% Insol.

To SHAKER SCREEN (4080# sand/hr.
184 gal/min. U

Oversize 1/32" in. Undersize
420# per hour/min. Tailings

NO.2 LOGS

68.92%B.P.L-6.2FeAl
per hr 20.92%FeAl.-6.11 Insol.

FLWASHEET (Continued)

NO. 2 Logs

Heads	Overflow	
64.60%B.P.L.-2.70%Fe.Al.	To SHAKER SCREEN	
14.75% Insol.	541# sand/hour	
	108 gal./hour	
	Over 1/32"	Undersize
	7.5#/hour	Tailings
NO. 2 TROMMEL	67.28%B.P.L.-3.05%Fe.Al.	
Heads	10.20% Insol.	
Heads	To bin.	
69.52%B.P.L.	To SHAKER SCREEN	
2.99% Fe.Al.	177 gal./min.	
6.85% Insol.	4500# sand/hour	
Finished product		Undersize
to bin.	Over 1/32"	Tailings.
	464# / hour	
	67.15%B.P.L.- 2.92%Fe.Al.	
	11.90% Insol.	
	To bin.	

Note

There is but one Shaker Screen ;Flow Sheet shows the product of the tailings from each machine onto the shaker screen.

Possible saving by screening the tailings from the entire plant to 1/32".

Location	%B.P.L.	%Fe.&Al.	%Insol.	Quantity saved per hour, Lbs	Quantity sand per hour, Lbs
FlatScreen	70.34	2.82	7.78	1812	21300
#1 Logs	67.70	3.10	9.42	810	5640
#1 Trommel	68.92	2.96	6.11	420	4080
#2 Logs	67.92	3.05	10.20	7.5	541
#2 Trommel	67.15	2.92	11.90	464	4500
		Total		3513.5	36061

This would make a saving of 38 Tons of marketable rock per day: In actual practice the fine rock saved by this method proved better than the other by an average of 0.5% B.P.L..

Addition to the Washer

From the foregoing data a screening of a portion of the washer with 1/32 screens was tried but this proved unsatisfactory for operative reasons and an addition was then decided upon to handle the tailing from the plant ; A shaker-screen was decided upon due to the quantity of material to be handled. It was found possible to incorporate this addition into the structure of the plant and save the construction of a separate plant , and in such a way that only the tailings from (#2 Logs/and #2 Trommel would need to be pumped onto the screen , the other tailing

flowing by gravity .

A sepearte bin was also built to take care of this fine rock in case it did not come up to expet-ations. The features of this bin are that it ties into the main bin and is high enough to clear a locomotive ,the bottom is made water-tight ,sloping to one side draining the water from off the locomotives through 1-1/2 inch pipes.

The attached blue-print gives the General Lay-Out and Detail as worked out for this addition and shows many of the localizims of this practice.